1 In an experiment to measure the rate of diffusion, a student placed cubes of agar jelly containing an indicator into dilute hydrochloric acid. The indicator changes from pink to colourless in acidic conditions.

The student used cubes of different sizes and recorded the time taken for the pink colour of each cube to disappear completely.

The student's results are recorded in Table 2.1.

Length of side of cube (mm)	Surface area of cube (mm^2)	Volume of cube (mm^3)	Surface area to volume ratio	Time taken for pink colour to disappear (s)	Rate of diffusion ($mm\,s^{-1}$)
2	24	8	3.0:1	50	0.020
5	150	125	1.2:1	120	0.021
10	600	1000		300	0.017
20	2400	8000	0.3:1	700	0.014
30	5400	27000	0.2:1	1200	0.013

Table 2.1

(a) (i) Calculate the surface area to volume ratio of the cube with 10 mm sides.

Show your working.

Answer = ... **[2]**

(ii) **Using the data in Table 2.1**, describe the relationship between the rate of diffusion and the surface area to volume ratio.

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..... **[2]**

(iii) Explain the significance of the relationship between rate of diffusion and the surface area to volume ratio for large plants.

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..... [2]

(b) Another student used the same raw data obtained in the experiment but calculated a different rate of diffusion for each cube. This student's results are shown in Table 2.2.

Length of side of cube (mm)	Time taken for pink colour to disappear (s)	Rate of diffusion ($mm\,s^{-1}$)
2	50	0.040
5	120	0.042
10	300	0.033
20	700	0.029
30	1200	0.025

Table 2.2

In this student's table, the calculation of the rate of diffusion is incorrect.

(i) Suggest the method used to calculate the rate of diffusion in Table 2.2.

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..... [1]

(ii) State why the method in **(b)(i)** is **not** correct.

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..... [1]

(c) In mammals, the lungs are adapted to enable efficient gaseous exchange.

The table below lists some of the adaptations of the lungs.

Complete the table explaining how each adaptation improves efficiency of gaseous exchange.

Adaptation	How this adaptation improves efficiency of gaseous exchange
squamous epithelium	....
large number of alveoli	....
good blood supply	....
good ventilation	....

[4]

[Total: 12]

2 Fig. 1.1 (a) is a diagram of a part of a mammalian lung.

Fig. 1.1 (b) is an enlargement of part of the lining of the bronchus.

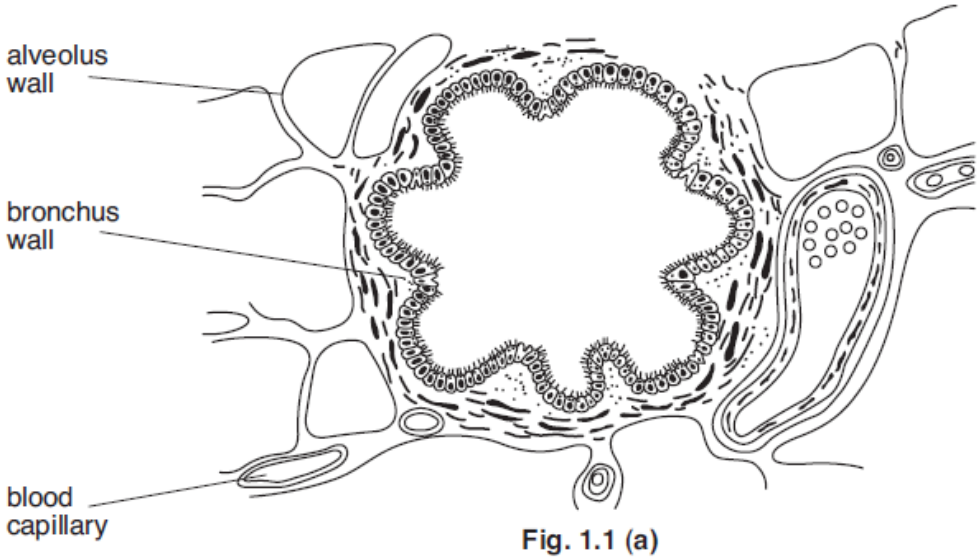

Fig. 1.1 (a)

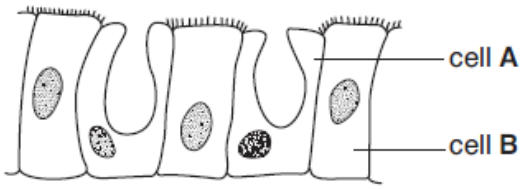

Fig. 1.1 (b)

(a) (i) Name the two types of cell, **A** and **B**, shown lining the **bronchus**.

A .....

B ..... **[2]**

(ii) Describe how cell types **A** and **B** work together to keep the lung surface clear of dust and other particles.

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..... **[3]**

(iii) The bronchus wall also contains smooth muscle fibres.

State the function of the smooth muscle fibres.

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..... [1]

(b) (i) Explain why blood capillaries and alveoli are very close together.

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..... [2]

(ii) The walls of the alveoli contain elastic fibres.

State the function of these elastic fibres.

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..... [1]

[Total: 9]

3 Fig. 2.1 shows a drawing of a part of the lung.

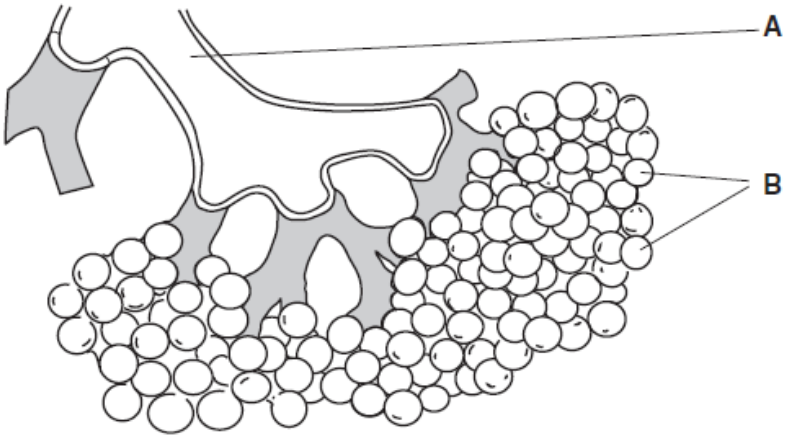

Fig. 2.1

(a) Name the structures labelled **A** and **B**.

A .....

B ..... **[2]**

(b) State **two** features of the structures labelled **B** that enable efficient gaseous exchange.

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..... **[2]**

(c) As part of an allergic response, certain cells in the lungs release histamine.

Histamine is a cell signalling molecule that stimulates smooth muscle in the wall of structure **A** to contract.

Suggest how histamine stimulates smooth muscle contraction.

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..... **[2]**

(d) Another action of histamine is to make capillary walls more permeable.

Suggest **two** effects this increased permeability may have on the surrounding tissues.

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..... **[2]**

[Total: 8]

4 Fig. 5.1 shows a spirometer, which is used to investigate lung function.

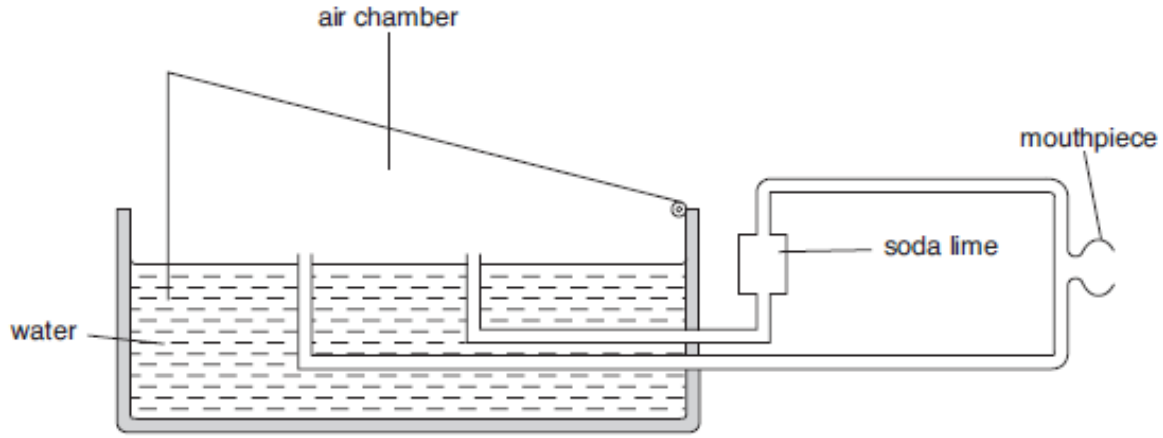

Fig. 5.1

(a) (i) Describe how the spirometer would be used to measure tidal volume.

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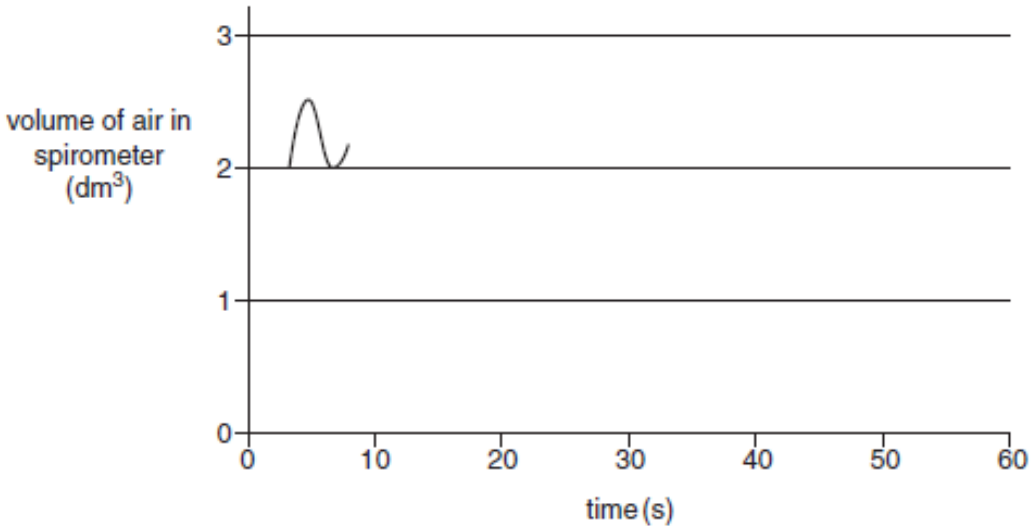
..... **[3]**

(ii) Using the axes below, complete the spirometer trace that you expect to see recorded from a healthy sixteen year old over **ten further breaths**, while at rest.



[2]

(iii) Describe how you could use a spirometer trace to measure the rate of oxygen uptake.

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..... **[3]**

(b) Suggest **two** factors that should be considered when carrying out a risk assessment for an experiment using a spirometer.

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..... **[2]**

[Total: 10]

5

(c) Using the mammalian **gaseous exchange system** as an example, explain how the different cells and tissues enable the effective exchange of gases.

In your answer, you should use appropriate technical terms, spelt correctly.

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..... **[5]**

6 **(a)** Describe and explain how the countercurrent system leads to efficient gas exchange across the gills of a fish.

[3 marks]

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[Extra space] .....

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(b) Amoebic gill disease (AGD) is caused by a parasite that lives on the gills of some species of fish. The disease causes the lamellae to become thicker and to fuse together.

AGD reduces the efficiency of gas exchange in fish. Give **two** reasons why.

[2 marks]

1 .....

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2 .....

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(c) **Table 2** shows some features of gas exchange of a fish at rest.

Table 2

Volume of oxygen absorbed by the gills from each dm^3 of water / cm^3	7
Mass of fish / kg	0.4
Oxygen required by fish / $cm^3\ kg^{-1}\ hour^{-1}$	90

(c) (i) Calculate the volume of water that would have to pass over the gills each hour to supply the oxygen required by the fish. Show your working.

[2 marks]

..... dm^3

(c) (ii) The volume of water passing over the gills increases if the temperature of the water increases. Suggest why.

[1 mark]

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7 Large insects contract muscles associated with the abdomen to force air in and out of the spiracles. This is known as 'abdominal pumping'. The table shows the mean rate of abdominal pumping of an insect before and during flight.

Stage of flight	Mean rate of abdominal pumping / dm^3 of air kg^{-1} $hour^{-1}$
Before	42
During	186

(b) Calculate the percentage increase in the rate of abdominal pumping before and during flight. Show your working.

Answer ..... %

(2 marks)

(c) Abdominal pumping increases the efficiency of gas exchange between the tracheoles and muscle tissue of the insect. Explain why.

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(2 marks)

(d) Abdominal pumping is an adaptation not found in many small insects. These small insects obtain sufficient oxygen by diffusion.

Explain how their small size enables gas exchange to be efficient without the need for abdominal pumping.

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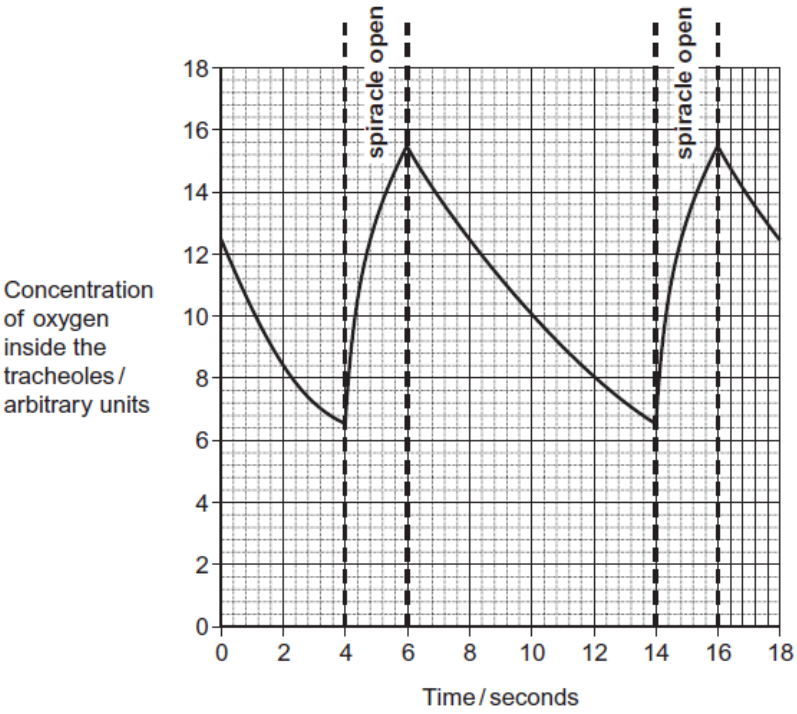
(1 mark)

The graph shows the concentration of oxygen inside the tracheoles of an insect when at rest. It also shows when the spiracles are fully open.



(e) Use the graph to calculate the frequency of spiracle opening. Show your working.

Frequency ..... times per minute
(2 marks)

(f) The insect opens its spiracles at a lower frequency in very dry conditions. Suggest **one** advantage of this.

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(1 mark)

(g) The ends of tracheoles connect directly with the insect's muscle tissue and are filled with water. When flying, water is absorbed into the muscle tissue. Removal of water from the tracheoles increases the rate of diffusion of oxygen between the tracheoles and muscle tissue. Suggest **one** reason why.

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(1 mark)